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Review Article

Research on Input Power Testing Technology of Smart Toilet

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Abstract: Input power is an important indicator for the safety testing of electrical and electronic products. Smart toilets have been frequently detected that the actual input power is inconsistent with the nominal power. Research and analysis show that the accuracy of the input power measurement results of the smart toilet mainly depends on the temperature control principle and power test method of the product. This article mainly discusses the characteristics of product temperature control, the testing method of mean and peak power and its characteristics, which will provide reference for the input power test of the smart toilet, and will improve the accuracy of power measurement.

Keywords: Input power; Mean power; Smart toilet; PID instant heating control

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1 Introduction

Input power is an important indicator of electronic and electrical safety testing. Many electronic and electrical products have some problems been detected in export or market quality checks. As the new favorite of the market, smart toilets have been found that its actual input power exceeds its rated power in various quality supervision and spot checks in the past 3 years. The problem of input power is mainly manifested in the large difference between the nominal rated power of the product and its measured value.

The determination of the input power depends on many factors, the most important one is the testing method. Many research and development companies fail to notice that the power measure method has a greater impact on the test results when determining the power. Generally, instruments are used to directly test the power and the importance of test methods and operating conditions is ignored, which will lead to deviations in results. Test method is the critical factor affecting the results, the input power test methods of smart toilets mainly include peak power and mean power.

2 Input power test method

2.1 Product features

The input power is mainly determined by measuring the comprehensive power consumption value of the smart toilet in normal use or maximum load conditions. Generally, the main power consumption components of smart toilets are water heater, seat heater and drying heater. Among them, the power consumption of the water heater is the largest, which is generally 800W to 1600W, followed by drying heater, which is about 200W to 300W, and the consumption of the seat heater is the smallest, which is about 50W, other energy-consuming components, such as DC motors, solenoid valves and PCBA are relatively low. Therefore, the correct measurement of the power consumption of the water heater is essential to accurately determine the rated power value of the smart toilet.

At present, the water heating modules used in smart toilets mainly include: an instant heating module and a heat storage heating module. The water heating power measurement will be affected by the input condition settings and materials. The input condition settings mainly include: heating mode, heating efficiency, inlet water temperature and outlet water temperature and

other parameter settings, which will directly affect the measurement results. In addition, the material influence is mainly reflected in the material of the waterway environment, because of its certain thermal conductivity, it will cause the temperature loss of the water in the transmission path and affect the power compensation, such as the influence of water tank material, silicone tube and flexible hose, even the ambient temperature will directly affect the power test results. Therefore, there are many factors affecting the input power.

In addition, through practical research, we found that even if the product is set under the same input conditions and material characteristics, different methods will still affect the accuracy of the input power measurement, that is, whether to use the peak power test method or the mean (integral) power test method. The selection of peak and mean power test methods mainly depends on the heating control method.

At present, most of the heating control methods of smart toilets adopt PID (Proportional Integral Derivative). As shown in Figure 1, the essence of PID working principle is to perform proportional, integral and deviation calculations on the differential value (e value), and to control the execution unit based on the result of the calculation. The water temperature control system of the smart toilet is composed of a PID controller, a sensor, a heating control PCBA and a heater. The system can smoothly correct the temperature deviation through water temperature feedback and it can process, realize the stable control of the water temperature, so as to ensure the stability of the outlet water temperature.

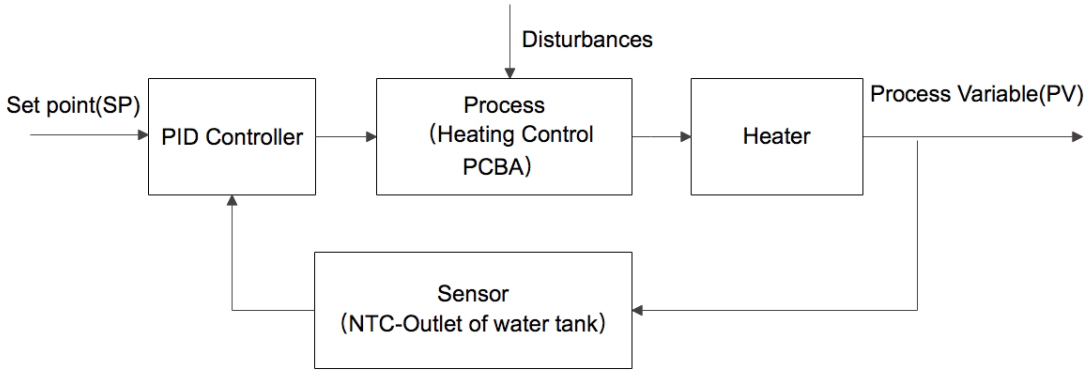

Figure 1 - WATER HEATER PID CONTROLLER

2.2 Peak power

It mainly refers to the maximum power value that the product can reach during the operating cycle. Generally, a power meter with Peak Hold or Max Hold function should be selected for measurement. Devices with this function will automatically capture the peak power (P.P.) value during the measurement and maintain the peak power value during the period.

For appliances with constant heating, the instantaneous power read during the power stabilization period is generally close to the peak power, and the peak power testing method can more quickly and accurately measure the rated power of the product with a representative operating cycle. Pay attention to the harmonics of the power signal during the testing process, otherwise some harmonics or ripples may cause the measured peak power to be falsely high. The laboratory should ensure that the power supply is filtered and grounded. In addition, the test should measure the maximum power value of the working cycle when the power is stable.

Most electric heating appliances, as shown in Figure 2b, have a relatively constant heating power during a representative period. Therefore, the peak power measurement method is also common. For example, most barbecue machines, electric kettles, toasters, grills, and hot pots on the market have a constant power per unit cycle.

2.3 Mean power (integral power)

The mean power is an active power $P = \frac{W}{T}$, which refers to the mean value of the integral of the instantaneous power emitted or consumed by the load in a unit period (or the power consumed by the load resistance). The formula can be expressed in integrals.

$$P = \frac{1}{T}\int_{-\frac{T}{2}}^{\frac{T}{2}} u(t)i(t)dt \qquad (1)$$

The general standard for household appliances GB4706.1 requires that if the power input varies

throughout the operating cycle, the power input is taken as the arithmetic mean value during a representative period[1].

According to the requirements of 10.1 in IEC 60335-1:2016 Ed.5.2, as shown in Figure 2c, if the power input varies throughout the operating cycle and the maximum value of the power input exceeds, by a factor greater than two, the arithmetic mean value of the power input occurring during a representative period, then the power input is the maximum value that is exceeded for more than 10 % of the representative period. Otherwise the power input is taken as the arithmetic mean value[2].

By analyzing the input power of the smart toilet, as shown in Table 1, it is found that the input power varies throughout the operating cycle, but during a representative period, the maximum input power does not exceed twice the mean value, as shown in Figure 2. a, therefore, the mean value is used.

the mean value reflects the mean power consumption in a certain time period. Each has its own reference value and advantages and disadvantages.

Rated power (input power) can help customers choose the right power supply and avoid connecting electrical appliances beyond the power supply system and cause unnecessary risks. For example, overcurrent protectors and fuses are sensitive to peak currents, and the conductors of the wire under high load will heat up and cause the risk of accelerated insulation aging. The mean power reflects the continuous energy consumption during the cycle, and the impact on the wire with current generated by the instantaneous peak power will be slightly smaller than the continuous mean power.

Therefore, the use of the correct method to obtain power has an important significance for the selection of appropriate installation conditions for electrical products. Especially for PTC products, the action time is

Table 1. Input power test value of Smart toilet water heating (Measured during a representative period)

Inlet water temperature	Peak power (W)	Mean power (W)
10℃	1585	1101
15℃	1233	901

The study found that the power obtained by the method of IEC 60335-1:2016 Ed 5.2 can more reasonably reflect the operating characteristics of the static heating heat pump water heater[4], and the PTC heating device with temperature control device, which makes up for the GB 4706.1-2005 defects in test methods of similar products.

milliseconds, and the sampling frequency of the test instrument is required to be at least 10 Hz.[5]

3.2 Country differences

With the globalization of trade, smart toilets have entered the international market, especially in China, Europe and North America. Certification and standards have become the basic requirements for global market

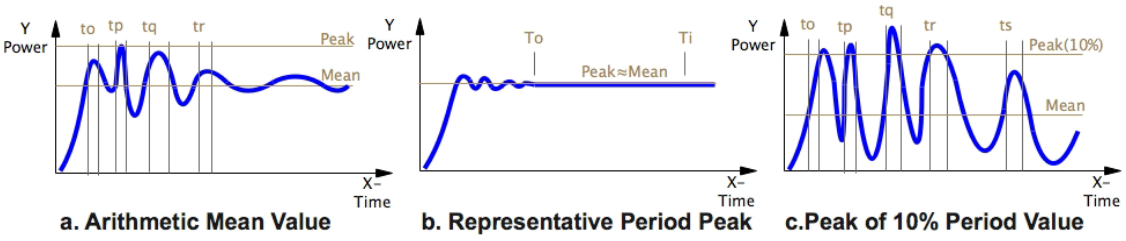

Figure 2 - TYPICAL CASE OF POWER CURVE

3 Comparison and analysis

3.1 Application characteristics

Peak power and mean power reflect the difference in power consumption of the product over time. The peak value can reflect the highest value of the power consumption of the product at a certain instant time, and

access and an important indicator of quality compliance. Compliance with target market standards has become an important indicator of product development for research and development companies. Input power is an important indicator of national electrical safety standards, it must be accurately measured and marked on the product nameplate., so that the rated power of the

product can be correctly stated.

Compared with the current international standards, the description of the input power measurement method in IEC60335-1 is the most clear one. The standard specifies the setting of parameters such as inlet water temperature, rated voltage, functional opening, measurement time and power measurement method during testing. China's current national mandatory standards are equivalent to the old version of IEC60335-1. For example, the current Chinese national standard GB4706.1:2005 is the same as the IEC60335-1:2004 edition 4.1 , and there are method differences with the current IEC60335-1:2016 version 5.2, as shown in Table 2. Europe and Australia have the same standard. There is a big standard difference in North America: Canada adopts CSA C22.2 No. 64, while the American UL1431 test method for input power is not as clear as IEC60335 series.

4 Conclusion

The principle of product temperature control and the applicable standard requirements of the target market are critical to power measurement. Only by selecting appropriate testing methods according to different heating principles and standard requirements can the correct power be measured. In particular, the standards among China, Europe, Australia and North America are quite different. In order to ensure the accuracy of the input power test results, and reduce the risk of incorrect nominal power ratings of industry development companies, appropriate operating conditions and parameters should be set in accordance with the functional characteristics of the product during the test.

Table 2. National differences in smart toilet input power test methods

Market & Certification	Standards	Input power limit range	Operating conditions
IEC CB	IEC60335-2-84 IEC60335-1	+5% or–10%	1）Test water temperature: (15±5)℃; 2）All circuits which can operate simultaneously being in operation; 3）Supplied at rated voltage; 4）Operated under normal operation； 5）Measurement when the power input has stabilized; 6）If the power input varies throughout the operating cycle and the maximum value of the power input exceeds, by a factor greater than two, the arithmetic mean value of the power input occurring during a representative period, then the power input is the maximum value that is exceeded for more than 10 % of the representative period. Otherwise the power input is taken as the arithmetic mean value.
China CQC	GB4706.53 GB4706.1	+5% or–10%	GB 4706.1:2005 is identical to IEC 60335-1:2004(Ed. 4.1), the requirement of clause 10.1 is: "If the power input varies throughout the operating cycle, the power input is taken as the arithmetic mean value during a representative period ."
Canadian CSA	CSA C22.2 No. 64	+5% or–10%	1) At normal operating temperature under full-load conditions. 2) Test under the rated voltage, if maximum and minimum voltages are marked, the voltage of the supply circuit shall be the arithmetic mean of the two values；[6] 3) Rated frequency.
American UL	UL1431	Not exceeding 110%	Operated under the condition of maximum normal load.[3] For example, the temperature and flow rate of test water should be able to make the product work under the maximum power condition as much as possible.

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